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ABSTRACT

Designed to examine the factors that contribute to student achievement, this study focused specifically on the relationship between physics achievement and selected teacher characteristics, student characteristics, and school and district characteristics. Questionnaires and attitude surveys were completed by 39 randomly selected Mississippi physics teachers (21 certified, 18 noncertified). To measure achievement in physics, the Mississippi State University Physics Achievement Test was administered to 616 physics students. Data were analyzed to determine the correlation between physics achievement and each of the 26 variables identified in the study. Consideration was also given to which combination of selected variables would serve as the best predictor of achievement in physics. Results indicated that teacher certification in chemistry, number of undergraduate hours in physics, student-reported average school grade of A, and a teaching load which included general science were the best predictors of achievement, collectively accounting for 48.7 percent of the variance. (ML)

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An Analysis of Factors Contributing to Achievement in Physics of Secondary Students in Mississippi Schools

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The decade of the eighties began with public attention focused on education. The weaknesses of public education and recommendations for improvement were released to the public in "A Nation at Risk: The Imperative for Education Reform" (American Association, 1983). Issues of particular interest to science educators are increased science requirements for high school graduation (Mississippi State Department of Education, July 25, 1984) and for college entrance (Board of Trustees, 1982), the lack of qualified science teachers (Shymansky & Aldridge, 1982), and the shift to an instructional system based on performance (Lawrenz, 1975).

The State of Mississippi became a leader in educational reform with the passage of House Bill No. 4, an act entitled The Education Reform Act of 1982. This act bases evaluation of teachers and accreditation of schools on student performance necessitating a closer examination of the factors that contribute to student achievement to determine effective methods of achieving desired student outcomes. The study focused on the relationship between physics achievement and selected teacher characteristics, student characteristics, and school and district characteristics.

The researcher hypothesized that there would be no correlation significantly different from zero between scores earned on the MSU Physics Achievement Test and any of the following variables: teacher preparation; area(s) and level(s) of certification; teaching experience, both total and in science; science subject(s) taught; teaching load; undergraduate grade point average in science; science inservice training; professional development through professional organization membership, reading of science periodicals, and NSF Institute attendance; gender and age of

teacher; teacher's attitude toward science; student's grade point average, gender, and participation in science fairs; the number of experiments and demonstrations conducted; laboratory and demonstration equipment available; class and school size; type of school district; per pupil expenditure; and the number of students on the federal lunch program. They also hypothesized that there would be no correlation significantly different from zero between scores earned on the MSU Physics Achievement Test and any combination of these variables.

Method

Subjects

The Mississippi State Department of Education supplied a listing of all personnel teaching physics in Mississippi during the 1984-1985 school year, the most recent listing available at the time. This listing also included the level and areas of certification of each of these teachers. From this group of 165 physics teachers, 91 certified and 74 noncertified, 50 certified physics teachers and 50 noncertified physics teachers were selected at random. These teachers were contacted, by mail on November 29, 1985, to determine their willingness to participate in this study. Those teachers agreeing to participate returned a postcard which gave the size of the physics class to which they would administer the physics test and the signature of the building principal giving permission for school participation.

To obtain the necessary participants, the 100 teachers initially selected were contacted two additional times, once by letter and once by phone. Fifty-one physics teachers agreed to participate, 26 certified and

25 noncertified in physics. Of these 51 teachers, 39 (21 certified, 18 noncertified) actually completed the questionnaire and the attitude survey and administered the test to their students. The intact classes of the teachers comprised the student sample. A total of 616 physics students were tested.

Measuring Instruments

The Mississippi State University Physics Achievement Test, one of several tests developed by members of the Mississippi State University Physics Department for use in their Annual MSU Physics Competition for High School Students, was used to measure achievement in physics. This test consists of 34 multiple choice questions in the content area of mechanics only, an area covered by most schools during the first semester of physics. Selection of this test was based on its availability, length, and content.

Content validity of the test was established by the expertise of the test developers, members of the Mississippi State University Physics Department. Internal consistency was estimated from the Cronbach's Coefficient Alpha on data obtained from the administration of similar forms of this test used in the Mississippi State University Annual Physics Competition. The test reliability was predicted to be .85. The Emporia Physics Test (EPT), Test I, Form A, consisting of content covering mechanics only was one of two physics tests selected for inclusion in a study of standardized tests by Morgenstern and Renner (1984). This test and the MSU Physics Achievement Test were administered by the researcher to two physics classes at a public high school in Mississippi. Concurrent validity was established by correlation of the MSU Physics Achievement

Test with the EPT, The Pearson correlation coefficient was .47. The reliability of this form of the EPT, as determined by the split half method, is 0.92 (Whitten & Sanders, 1964).

The Teacher Questionnaire was planned and developed by the researcher to collect information on the following variables: gender; age; undergraduate grade point average in science courses; undergraduate grade point average in science courses; undergraduate and graduate hours in science, mathematics, and education; areas and levels of certification; teaching experience; teaching load; experiments and demonstrations conducted; equipment available for experiments and demonstrations; average class size; participation in National Science Foundation Institutes and inservice devoted to science; participation in professional organizations; science periodicals read regularly; and school size. The questionnaire was examined by five members of the Mississippi State University College of Education to determine content validity.

The student answer sheet was used to obtain information about student variables. The students were instructed by their teachers to mark their answer sheets to indicate gender, grade point average, and science fair participation.

To assess teacher attitude toward science, a semantic differential instrument was used. The adjective pairs used were selected from a list developed by Osgood and Suci (1977). The adjective pairs which had a coordinate of 2.00 or more on the evaluative dimension were used. From a list of 50 adjective pairs, 19 were used. To determine reliability, the semantic differential scale was administered to teachers at a public high school in Mississippi. The reliability, as measured by Cronbach's alpha, yielded a coefficient of .88.

Method of Data Collection

Packets, containing a physics achievement test for each student, student answer sheets, the Teacher Questionnaire, a semantic differential, instructions for participation, and a postpaid mailer, were mailed to 51 physics teachers on February 11, 1986. The teachers were directed to administer the tests at their convenience during the week of February 17-21, 1986, and return the answer sheets, the Teacher Questionnaire, and the semantic differential to the researcher in the postpaid mailer provided. Thirty-nine teachers administered the Mississippi State University Physics Achievement Test to 616 physics students and returned the required data. The tests were machine scored and the results of information on teacher and student variables tabulated. For purposes of this study, a mean achievement score for each teacher was obtained from students' scores, and this mean was used to determine all correlations between achievement in physics and all other variables.

The Bureau of Educational Research and Evaluation at Mississippi State University provided information on the type of school district, the district percent of students on the federal lunch program, and the per pupil expenditure for each district. This information was for the 1983-1984 school year, the most recent for which the data could be obtained.

Analysis of Data

Prior to investigating the hypotheses, the data were analyzed to obtain the descriptive statistics. The frequencies, means, and standard deviations for the variables were determined (see Table 1). Data were analyzed using the Statistical Package for the Social Sciences (SPSS)

(Nie, Jenkins, Steinbrenner, & Bent, 1975).

Data were analyzed through the use of a simple correlation to determine the correlation between physics achievement and each of the 26 variables studied. A multiple regression analysis was used to determine what combination of variables would serve as the best predictor of physics achievement. The .05 alpha level was employed for determining the entry of independent variables into the regression equation. Variables, in a stepwise manner, were allowed to enter the regression as long as they contributed a statistically significant (.05 level) amount of variance to the analysis. SPSS (Nie et al., 1975) was used to perform the analyses.

Results

To determine what correlation, if any, would be found between each of the independent variables and achievement in physics, a Pearson-product moment correlation was computed independently for each variable. Table 2 provides the result of this analysis.

Correlating significant at the .05 level were certification in chemistry ($r = .42$), the number of graduate hours in chemistry ($r = .38$), the percent females in physics ($r = -.37$), the number of undergraduate hours in physics ($r = .30$), the number of years of teaching experience in physics ($r = .30$), a teaching load which included general science ($r = -.30$), and a teaching load which included biology ($r = -.29$). Correlating significantly at the .10 level were the number of graduate hours in physics ($r = .22$), a teaching load which included chemistry ($r = .22$), the teacher's undergraduate grade point average in science courses ($r = .22$), the amount of physics equipment available ($r = .23$), the type of periodical read on a regular basis ($r = -.24$), the percent of

students reporting a high school grade average of A (r = .25), and the type of school district (r = -.26).

The negative correlation for the percentage of females in the physics class indicated that the larger the percent of females the lower the achievement in physics. Students of teachers whose teaching load included general science and biology were lower in physics achievement as indicated by the negative correlation. The negative correlation for the type of periodical shows higher achievement for those students whose teachers read science sections of general news magazines rather than science journals or periodicals. The negative correlation for type of school district favored physics achievement in schools in municipal districts.

Teachers whose students achieve in physics, as indicated by these correlations, are certified in chemistry, have graduate hours in chemistry, are better prepared in physics at the undergraduate and graduate levels, have a high undergraduate grade point average in science courses, have experience in teaching physics, and read the science sections of general news magazines on a regular basis. They have a teaching load which includes chemistry but does not include general science or biology. Their students are more successful if they are students who have an A high school average, are in a class that is largely male, and are in a school in a municipal school district which has equipment available for experiments and demonstrations.

The major research question was to determine what combination of the selected variables would serve as the best predictor of achievement in physics. Table 3 provides a list of the predictor variables. Each unique variable explained a statistically significant amount of variance (.05 level) when added. These variables were teacher certification in

chemistry, the number of undergraduate hours in physics, the percentage of students reporting an average high school grade of A, and a teaching load that included general science.

The best predictor of achievement in physics, as determined by forward stepwise multiple regression, was teacher certification in chemistry, explaining 17.7% of the variance. This variable had an F-value of 7.97, significant at the .05 level. The number of undergraduate hours in physics explained another 11.3% of the variance. The F-value of this variable was 5.72, significant at the .05 level. The percentage of physics students reporting an average high school grade of A, explaining an additional 9.60% of the variance, had an F-value of 5.38, significant at the .05 level. A teaching load which included general science explained an additional 10.2% of the variance with an F-value of 6.75, significant at the .05 level. The entire predictor set explained 48.7% of the variance and had an F-value of 8.06, significant at the .05 level (df 4, 34).

The predictor variable teacher certification in chemistry was an indication of the need for preparation of the teacher in physical sciences, not just in physics. The negative correlation of a teaching load in general indicated that students whose teachers teach general science are not likely to achieve at as high a level in physics. These teachers do not normally have the background in physics that teachers of only physics and chemistry do.

Conclusions/Implications

Conclusions

Based on the results obtained from this limited sample of Mississippi physics teachers, the following conclusions were reached:

1. Teacher preparation in chemistry and physics and undergraduate grade point average are related to achievement in physics. The more hours in physical sciences the teacher had, the higher the level of achievement of their students in physics.

2. Teaching experience is important in promoting achievement in physics. Experience allowed teachers to overcome a lack of preparation in the area and was more important in achievement than was certification in the area.

3. Classes with a larger percentage of females than males achieved lower in physics than classes composed largely of males.

4. Students of teachers whose teaching load included general science and biology did not achieve as well in physics. In general, teachers of general science and biology did not have adequate preparation in the physical sciences and experience in teaching physics.

5. Physics students whose teachers also taught chemistry achieved at a higher level.

6. Students from schools in municipal districts achieved higher in physics.

7. Classes composed largely of students having an A high school average did better in physics.

8. Certification in chemistry increased achievement in physics.

9. Levels and areas of certification were not significantly related

to predicting achievement in physics and chemistry.

10. Teachers did not find professional development important as evidenced by their lack of participation in professional organizations and science inservice activities and by their lack of reading of current science literature.

Implications

Several implications may be drawn from the conclusions reached from the data presented in this study. These implications are of value specifically to science educators and may provide areas of concern to educators in general.

There is a need for more preparation in physics, particularly in physics at the undergraduate level. Undergraduate hours in physics served as a predictor variable of and correlated significantly with physics achievement. The physics teachers in this study had an average of 12.4 undergraduate hours in physics, a number less than that required for physics certification in Mississippi. This lack of teacher preparation is a issue that must be addressed by science educators.

The significant correlation between certification in chemistry and achievement in physics supports the new certification area in Mississippi which provided a combined chemistry-physics certification. Teachers need preparation in both areas to have the physical science background to be an effective physics teacher.

Teachers gain in ability through teaching experience. Teachers can only gain this experience by remaining in the teaching profession. Efforts should be made by districts to retain science teachers by providing financial incentives and personal satisfaction.

Opportunities for teachers to develop professionally and to increase their knowledge of science through meaningful inservice sessions is needed. A lack of teacher participation in professional development was shown by this study.

Some support for the consolidation of Mississippi schools is provided by the data showing that students in municipal districts achieved higher in physics than students in county or consolidated districts. There was a positive correlation between achievement in physics and the amount of equipment available for physics experiments. Schools in municipal districts are likely to be larger, have more resources to provide equipment for experiments and have a more comprehensive curriculum than county or consolidated line schools.

Validation of the grading process is provided by the physics predictor variable, percent of students having a high school average of A. The students who receive high grades in all subjects can be expected to do well in physics.

Certification may not be providing teachers with the preparation they need to teach physics. Very little evidence was provided in support of the certification process. The correlation between certification in chemistry and achievement possibly indicated that the teachers who become certified in chemistry take more physics courses and are generally better prepared in the physical sciences.

Table 1

Means and Standard Deviations of Criterion Variables and Physics Achievement

Variable	$\bar{X}$	SD
Physics Achievement	9.4	1.7
Undergraduate Hours		
Biology	17.9	11.7
Chemistry	17.6	11.7
Physics	12.4	6.3
Earth Science	2.2	3.1
Mathematics	18.1	11.9
Education	19.3	11.8
Graduate Hours		
Biology	5.3	7.0
Chemistry	7.3	9.0
Physics	7.8	9.1
Earth Science	1.2	3.0
Mathematics	5.8	9.9
Education	13.3	14.4
Certification[a]		
General Science	1.3	1.0
Biology	.8	.8

Variable	$\bar{X}$	SD
Certification (continued)		
Chemistry	.7	.7
Physics	.8	.8
Earth Science	.0	.0
Teaching Experience	13.9	9.1
Physics Teaching Experience	8.6	7.8
Teaching Load[b]		
General Science	.1	.3
Biology	.2	.4
Advanced Biology	.3	.4
Chemistry	.5	.5
Advanced Chemistry	.1	.3
Physics	.9	.2
Advanced Physics	.1	.2
Physical Science	.1	.3
Advanced Physical Science	.0	.0
Other Sciences	.1	.3
Other Subjects	.3	.5
Undergraduate Grade Point Average in Science	3.7	1.0
Physics Experiments	12.5	8.2

Variable	$\bar{X}$	SD
Physics Demonstrations	12.4	8.2
Physics Experiment Equipment	15.1	9.9
Physics Demonstration Equipment	16.8	25.1
Physics Class Size	18.1	6.2
National Science Foundation Institutes	1.2	1.7
Inservice	1.8	3.2
Professional Organizations	.6	.8
Type of Professional Organizations[c]	.8	1.1
Number of Periodicals Read Regularly	.9	1.1
Type of Periodicals[d]	1.0	1.0
School Size	490.1	333.1
Attitude Toward Science	99.8	13.6
Percent Females in Physics	44.1	18.6
Percent Science Fair Participation	54.6	32.6
Percent Students with a High School Average of A	37.7	18.9
Percent Students with a High School Average of B	47.3	14.9
Percent Students with a High School Average of C	11.9	13.3
Percent Students with a High School Average of D	1.2	3.5

Variable	$\bar{X}$	SD
Percent Students with a High School Average of F	.1	.9
District Type[e]	1.6	.6
Percent of Students on Federal Lunch Program	63.9	14.9
Per Pupil Expenditure	1786.1	465.3
Age[f]	4.8	1.7
Gender[g]	1.4	.5

Note. Teacher n = 39.

[a]1 = A, 2 = AA, 3 = AAA, 4 = AAAA. [b]1 = yes, 0 = no. [c]1 = local and/or state, 2 = national, 3 = both. [d]1 = news magazine, 2 = professional journal, 3 = both. [e]1 = municipal, 2 = county, 3 = consolidated. [f]1 = under 25, 2 = 25-29, 3 = 30-34, 4 = 35-39, 5 = 40-44, 6 = 45-50, 7 = above 50. [g]1 = male, 2 = female.

Table 2

Simple Correlations Between Achievement in Physics and Teacher, Student, and School & District Variables

Variable	r
Undergraduate Hours in Biology	.08
Undergraduate Hours in Chemistry	.05
Undergraduate Hours in Physics	.30**
Undergraduate Hours in Earth Science	-.05
Undergraduate Hours in Mathematics	.15
Undergraduate Hours in Education	.04
Graduate Hours in Biology	.12
Graduate Hours in Chemistry	.38**
Graduate Hours in Physics	.22*
Graduate Hours in Earth Science	.12
Graduate Hours in Mathematics	-.07
Graduate Hours in Education	.09
Certification in General Science	-.02
Certification in Biology	.12
Certification in Chemistry	.42**
Certification in Physics	.18
Certification in Earth Science	Could not be computed

Variable	r
Teaching Experience	.04
Physics Teaching Experience	.30**
Teaching Load - General Science	-.30**
Teaching Load - Biology	-.29**
Teaching Load - Advanced Biology	.15
Teaching Load - Chemistry	.22*
Teaching Load - Advanced Chemistry	.11
Teaching Load - Physics	.18
Teaching Load - Advanced Physics	.00
Teaching Load - Physical Science	-.08
Teaching Load - Advanced Physical Science	Cannot be computed
Teaching Load - Other Sciences	-.15
Teaching Load - Other Subjects	-.15
Undergraduate Grade Point Average in Science	.22*
Physics Experiments	.19
Physics Demonstrations	.00
Physics Experiment Equipment	.23*
Physics Demonstration Equipment	-.02
Physics Class Size	.00
National Science Foundation Institutes	-.15

Variable	r
Inservice	-.01
Professional Organizations	.16
Type of Professional Organizations	.07
Number of Periodicals Read Regularly	-.07
Type of Periodicals	-.24*
School Size	.14
Attitude Toward Science	.03
Percent Females in Physics	-.37**
Percent Science Fair Participation	-.06
Percent Students with a High School Average of A	.25*
Percent Students with a High School Average of B	-.18
Percent Students with a High School Average of C	-.03
Percent Students with a High School Average of D	-.09
Percent Students with a High School Average of F	-.14
Type of School District	-.26*
Percent of Students on Federal Lunch Program	.09
Per Pupil Expenditure	.12
Age of Teacher	.18
Gender of Teacher	-.18

*$p < .10$, **$p < .05$

Table 3

Predictors of Physics Achievement for High School Students From Teacher, Student, and School & District Variables

Variable	Multiple R	R square	R square added	Simple r	F to Enter	df
Certification in Chemistry	.4210	.1773	.1773	.42	7.97*	1,37
Undergraduate Hours in Physics	.5386	.2901	.1129	.30	5.72*	1,36
% Students Having High School Average of A	.6203	.3847	.0946	.25	5.38*	1,35
Teaching Load - General Science	.6976	.4866	.1019	-.30	6.75*	1,34
Total Predictor Set	.6976	.4866			8.06*	4,34

*$p < .05$

[a]F for overall regression for the four predictor variables

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